Review article

The ‘John Thomas’ sign and pelvic fractures—Fact or humorous myth?: A systematic review and meta-analysis

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ARTICLE INFO

Article history:

Received 28 September 2017

Accepted 21 October 2017

Available online 24 October 2017

Keywords:

John Thomas sign

Penile shadow

Penis shadow

Throckmorton sign

Oram's sign

Ormr sign

Ray camel sign

Solooki sign

ABSTRACT

Objectives: An incidental and sometimes humorous finding on an Antero-Posterior (AP) pelvis X-ray view is that of the John Thomas Sign (JTS), which is defined as positive, when the penile shadow points towards the side of a hip or pelvic fracture in male patients. Despite previous research reports and studies performed on the JTS sign, uncertainty with regards to its clinical relevance still remains. The objective of this review was to assess the clinical validity and accuracy of this sign by performing a systematic review and meta-analysis.

Methods: In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a systematic search was performed (May 2017), using the following databases: BMJ best practice, Cochrane Database of Systematic Reviews, EMBASE, PubMed and Scopus. Studies comparing the predictability of the JTS were critically appraised. The summary effect (and 95% CI) was estimated using a random effect model and the Restricted Maximum Likelihood Method. The pooled sensitivity as well as the summary effect log odds ratio was determined. Selected studies were further ranked for quality and relevance using the Critical Appraisal Skills Program (CASP) (Oxford 2013) tool. **Results:** In total, nine articles were isolated and assessed. A total of 1942 participants were included. The mean sample size amongst these included studies was 243 participants with a median of 198 participants. Since the necessary data needed for the Meta-analysis was only present in the 6/9 studies assessed, these 6 were analyzed further. The JTS was positive in 1089 out of 1439 patients with a pooled sensitivity of 75.7% (95%CI, 73.4%–77.9%). There was a large variation in the sensitivity and specificity amongst studies, accounting for a non-significant summary Odds Ratio effect of -0.03.

Conclusions: Based on this review, there is insufficient statistical evidence to support the reliability of the JTS to predict the laterality in the case of a hip fracture on the standard AP pelvis x-ray.

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1. Introduction

Hip and pelvic fractures are a common Trauma, Orthopaedic and Emergency Department (ED) presentation that is associated with a 10%–13.4% mortality and a severe complication rate of

12.5%.^{1,2} A combination of clinical and radiological findings is required to confirm the diagnosis of pelvic and hip fractures. A 90–98% sensitivity of an Anterior-Posterior (AP) pelvis X-ray in diagnosing fractures has been reported, whereas this sensitivity is increased to 100% when either computed tomography (CT) and/or magnetic resonance imaging (MRI) is utilised.³ An incidental and sometimes humorous finding on an antero-posterior (AP) pelvic X-ray view is that of the John Thomas Sign (JTS). This sign is defined as positive, when the penile shadow points towards the side of a hip or pelvic fracture in male patients.⁴ Few studies have objectively described the diagnostic value of the JTS. There is, however, a need to explore the literature regarding this sign as some studies have

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suggested a 'higher than chance' correlation between the JTS and a unilateral hip fracture.⁵ To better define the role, significance and statistical predictive value of the JTS in the lateralization of hip or pelvic fractures in the trauma setting, a systematic review and meta-analysis was performed.

2. Methods

2.1. Search strategy

A search strategy was developed to identify studies that reported on the sensitivity and/or specificity of the JTS in lateralizing unilateral hip or pelvic fractures. The following databases: BMJ best practice, Cochrane Database of Systematic Reviews, EMBASE, PubMed and Scopus was searched (March 2017) using the terms: 'John Thomas sign', 'penile shadow', 'penis shadow', 'Throckmorton sign', 'Oram's sign', 'Ormr sign', 'Ray camel sign' and 'Solooki sign'. A further reference search was performed on all the papers retrieved in this review, to retrieve any additional, relevant, articles that may have been missed in the database search. Language restrictions were not applied.

2.2. Study selection

Studies considered for inclusion met the following criteria: (i) the studies were clinical publications and (ii) studies reported either the sensitivity, specificity or provided detail with regards the positive versus negative sign findings. All published studies relating to the topic, including letters to the editor and conference papers were eligible for inclusion. Single case reports were however excluded.

2.3. Definition of JTS

For the purpose of this review, a positive JTS was regarded as the presence of a penile shadow (on AP pelvic x-ray) pointing towards the side of the hip or pelvic fracture, whereas a negative JTS was defined as the concomitant presence of a penile shadow pointing towards the midline or the opposite (contralateral) side of the fracture.

2.4. Data extraction and methodological quality evaluation

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines,⁶ were adhered to during this review. After the search was performed, all authors collectively

assessed for relevance, applicability and exclusion. Selected studies were ranked for quality and relevance using the CASP (Critical Appraisal Skills Program) tool⁷ (Table 1). Relevant studies were assessed based on the following categories; study type, aim, participant characteristics, definition of JTS or synonymous term used, sensitivity, specificity, positive and negative findings as well as the respective author comments and opinions. These findings were systematically tabulated (Table 2). Conflicting entries, disagreements and differences were resolved by consensus amongst all reviewers.

2.5. Data synthesis and statistical analysis

Sensitivities and specificities were extracted from the relevant studies,^{4,5,8–14} where available. These values were used to calculate the Log Odds Ratio and associated 95% confidence interval for each study. The summary effect (and 95% CI) was estimated using a random effect model and the Restricted Maximum Likelihood Method.^{15,16} Heterogeneity among studies was estimated using the I²-statistic.¹⁷ All data analysis was completed in R¹⁸ using the Metafor package.¹⁶ Since the pooled sensitivity and specificity was divergent, the Odds Ratio was used as a summary metric.

3. Results

3.1. Search

The search yielded the following: BMJ best practice (0), Cochrane Database of Systematic Reviews (0), EMBASE (5), PubMed (62) and Scopus (148). The articles were screened for both duplicates and content. Thirty-six duplicate and 169 unrelated entries were removed. No additional articles were identified from the references found within the selected papers. The remaining ten articles had full text available and were independently reviewed by the researchers. One article was excluded because it was a single case report. Nine articles were finally included in this review (Fig. 1).^{4,5,8–14} All except one study,¹¹ was published in English.

3.2. Variation of study definitions of the JTS

Although, a slight variation in the definition of a positive JTS was present, each study assessed a positive JTS where the penile shadow pointed to the side of the fracture.

Table 1

Details of CASP⁷ (Oxford: Critical Appraisal Skills Program) tool used to assess studies included for review (Key: Y:yes; N:no; CT: can't tell).

Authors	Thomas et al. ⁸	Jeys ⁵	Mouzopoulos et al. ⁹	Ya'ish & Baloch ¹⁰	Brink et al. ¹¹	Solooki & Vosoughi ¹²	McNeillis et al. ¹³	Chan ¹⁴	Murphy et al. ⁴
Did the study address a clearly focussed issue?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the cohort recruited in an acceptable way?	Y	Y	CT	Y	Y	Y	Y	CT	Y
Was the exposure accurately measured to minimize bias?	Y	CT	CT	Y	Y	Y	Y	CT	Y
Was the outcome accurately measured to minimize bias?	CT	CT	CT	Y	Y	Y	Y	CT	Y
Have the authors listed all confounding factors?	N	Y	N	Ys	N	Y	N	N	Y
Have the authors taken account of all the confounding factors?	N	Y	N	Y	N	Y	N	N	Y
Was the follow-up complete enough?	Y	CT	CT	Y	CT	N	CT	CT	Y
Was the follow-up long enough?	Y	CT	CT	Y	CT	N	CT	CT	Y
Do you believe the results?	Y	Y	N	Y	N	N	Y	N	Y
Can the results be applied to a local population?	N	N	N	Y	N	N	N	N	Y
Do the results of the study fit with other available evidence?	N	Y	N	Y	N	N	Y	Y	Y

Table 2

Summary of literature included for review (Key: #: Fracture; JTS: John Thomas Sign).

1	Manuscript Title	Authors (Ref)	Year	Language	Study type	Study Aim	Study Definition of a Positive JTS	Study Term utilised	Total sample (Subjects with and without #)	Subjects with #	Patients with #		Sensitivity of JTS	Specificity of JTS	Respective Author's Conclusion
											JTS +ve	JTS –ve			
1	John Thomas sign: common distraction or useful pointer?	Thomas et al. ⁸	1998	English	Retrospective	Examine sensitivity and specificity of JTS for hip fractures.	Penis inclined towards #	John Thomas sign	195	130	91	39	66.9% (95% CI, 58.33%–74.74%)	66.1% (95% CI, 52.61%–77.92%)	Predictive
2	Yorkshire men straight to the point, or not? Validation of the John Thomas Sign	Jeys ⁵	2000	English	Retrospective, blinded	To evaluate JTS in the northern hemisphere compared to New Zealand.	Penis points toward # on AP X-ray	John Thomas sign	Not defined	60	22	38	45.8% (95% CI, 28.34%–65.67%)	64.7% (95% CI, 43.86%–80.07%)	Environmental factors, inaccurate, should not be used
3	Does penis radiological shadow indicate the side of hip fracture?	Mouzopoulos et al. ⁹	2007	English	Retrospective	Test if radiological penis shadow indicates side of pelvis fracture.	Penis points toward # on AP X-ray, if displaced # occurs	Penile shadow	712 (No control group)	712	678	34	95.4% (95% CI, 93.7%–96.8%)	Not defined	Accurate
4	John Thomas Sign: Truth or Myth?	Ya'ish & Baloch ¹⁰	2007	English	Retrospective	To evaluate the diagnostic accuracy of JTS.	Penis points toward #	John Thomas sign and Throckmorton sign	200	100	30	70	30.0% (95% CI, 21.2%–40.0%)	86.0% (95% CI, 77.6%–92.1%)	Inaccurate
5	Oram's sign for hip or pelvic disorder	Brink et al. [11]	2009	Danish	Retrospective	Evaluate sign for clinical relevance, in determining side of pelvic fracture.	Penis points toward pathology on AP X-ray	Oram's sign	62	51	28	23	75.6% (95% CI, 58.80%–88.23%)	8.0% (95% CI, 0.98%–26.03%)	Inaccurate OA and #
6	John Thomas sign: is it helpful to determine the lower limb fracture?	Solooki & Vosoughi ¹²	2010	English	Prospective	Evaluate the helpfulness of JTS in determination of lower limb fracture.	Penis points toward #	John Thomas sign and Solooki sign	99 (No control group)	99	91	8	91.0% (95% CI, 83.6%–95.8%)	Not defined	Helpful Also included 401 other pts with other LL #
7	Can John Thomas help identify hip fractures? A retrospective study and combined analysis	McNeillis et al. ¹³	2011	English	Retrospective, blinded	Determine if JTS reliably predicts side of post-traumatic hip fractures.	Penis points toward # on AP X-ray	John Thomas sign	414	187	103	84	55.9% (95% CI, 48.46%–63.17%)	54.4% (95% CI, 47.68%–60.98%)	JT points away from side with no #
8	John Thomas sign: What does it stand for?	Chan ¹⁴	2014	English	Retrospective	Examine sensitivity of JTS to indicate hip fracture in the ED.	Penis points toward # on AP X-Ray	John Thomas sign	Not defined	Not defined	Not defined	Not defined	19.0%	Not defined	Not reliable, PPV = 12%
9	John Thomas sign-a memorable but misleading sign in hip fractures	Murphy et al. ⁴	2014	English	Retrospective	Evaluate the accuracy, and examine the phenomenon of eponymous signs.	Penis points toward # on AP X-ray	John Thomas sign	200	100	46	54	46.0% (95% CI, 35.9%–56.3%)	8.0% (95% CI, 3.52%–15.16%)	Inaccurate

Fig. 1. Study flow diagram.

3.3. Design of included studies

Eight of the studies,^{4,5,8–11,13,14} were cohort retrospective studies reviewing patient report forms, with two,^{5,13} using a blinded review process to assess the accuracy of the JTS. A further two studies in the retrospective group were Letters to the Editor or as a response to a previous article,^{8,9} with another two being conference presentations.^{7,14} Only one study was a prospectively conducted.¹²

3.4. Overall and study sample sizes

A total of 1942 participants were included with a mean sample size of 243 participants and a median of 198 participants. The study size in the reviewed articles varied from 712 participants in the largest study,⁹ to 62 participants in the smallest.¹¹ One article (letter to the editor) did not report on the number of subjects included in the control group⁵, whereas another publication (conference abstract) only reported on the sensitivity of the sign but did not include a study sample size.¹⁴

Fig. 2. Forest plot of the probability of ipsilateral hip fracture in patients with a positive John Thomas (penile shadow) sign in 6 published studies including 1121 patients. Results are expressed as log odds ratio and 95% confidence intervals. Pooled analysis $p = -0.966$, heterogeneity test $I^2 = 94.49\%$ [95% CI: 85.2%–99.1%]. For simplicity in presentation, only the numbers of fractures were stipulated in this study. Total sample size is not stipulated.

3.5. Aims of included studies

The studies included in the review had slightly different aims, but all the studies attempted to provide objective data on the accuracy of JTS. One study attempted to assess the accuracy of JTS in hip, pelvic as well as all other lower limb fractures. Subjects with other lower limb fractures were excluded from the final sample within this review.¹² The remaining studies assessed the accuracy of JTS for hip/pelvic fractures with the intent to provide recommendation on its use when evaluating standard AP pelvic radiographs.^{4,5,8–11,13}

3.6. Region of origin and participant age

Eight of the articles identified the location of the participants and included two from the United Kingdom,^{5,10} one each from Australia,¹⁴ New Zealand,⁸ Ireland,⁴ Denmark,¹¹ Iran,¹² and Greece.⁹ Only four studies reported on samples mean age that ranged between 75.3 to 78.6 years.^{5,9,10} In contrast, the mean reported age was 36 years in another study.¹²

3.7. Sensitivity, specificity and odds ratio of JTS

The JTS was positive in 1089 out of 1439 patients with a fracture with a pooled sensitivity of 75.7% (95%CI, 73.4%–77.9%). There was a large variation in the sensitivity and specificity amongst studies, accounting for the non-significant summary odds ratio effect of -0.03 .

3.8. Meta-analysis

Only six studies were included in the meta-analysis (Fig. 2).^{4,5,8–11,13} Those that were not included did not have the necessary data within their respective published reports. The log odds ratio (log OR) for each study was calculated and plotted against other studies (Fig. 2). Results varied widely from -2.60 [95% CI: -3.4 to -1.8] to 1.66 [95% CI: 1.0 – 2.3]. A summary effect model was computed from these studies, yielding a log OR of -0.03 [95% CI: -1.3 – 1.2]. The model's heterogeneity was assessed using the I^2 statistic.¹⁷ The analysis return a value of 94.5% [95% CI: 85.2%–99.1%] indicating a degree of heterogeneity. The majority of the heterogeneity was attributed to inter-study variability whereas sampling error accounted for a small proportion.¹⁹

4. Discussion

The objectives of this study were to report on the reliability and validity of the JTS, by identifying and analyzing research on the sign and reporting on its sensitivity and specificity, and the clinical applicability of the sign. These results have shown that there is congruency in the definition of the sign, (Fig. 3). However, there was a large variation between studies assessed, with regards to its underlying sensitivity and specificity, (Table 2).

The article conducted by Solooki et al., reported on JTS in both pelvic and lower limb fractures.¹² The authors of that study found it relevant to comment on the findings, namely, the more distal the fracture, the lower the sensitivity and specificity of the JTS. This

Fig. 3. Illustration of the Positive and Negative JTS (John Thomas Sign) (depicted on pelvic radiographs (Fig. 3A, B) and an artist's sketch (Fig. 3C, D)).

3a. Negative JTS sign, where penile shadow on pelvic X-Ray points away from the fracture side (left acetabular fracture).

3b. Positive JTS sign, where penile shadow on pelvic X-Ray points towards the fracture side (left acetabular fracture).

3c. Schematic outline of a negative JTS sign, where penile shadow (arrows) is neutral or points away from the side of the fracture (left neck of femur fracture).

3d. Schematic outline of a positive JTS sign, where penile shadow (arrows) points towards the side of the fracture (left neck of femur fracture).

was the only study that investigated JTS in lower limb fractures. Historically, its use has always been associated with hip or pelvic injuries. These authors further concluded that JTS is inaccurate in the clinical application and diagnosis of lower limb fractures.¹²

Although the pooled sensitivity of 75.7% (95%CI, 73.4%–77.9%) can be regarded as “fair” in determining the side of a fracture when a fracture is present, the meta-analysis results (summary odds ratio) demonstrate that the JTS is unable to determine the laterality of a fracture with any degree of certainty. Furthermore, the very large I^2 value indicates a significant degree of discordance between the results of the studies that were included in the meta-analysis. This study further emphasizes the poor performance of this sign in identifying fractures.³

In low income settings, this genital asymmetry may be an attractive diagnostic criterion for lateralizing the side of a pelvic fracture in males, as there may not be access to specialized radiological equipment. However, with the variations in sensitivity and specificity of JTS and such a high sensitivity for x-rays the authors concluded that JTS and the laterality (asymmetry of the penis) is an unreliable ‘pointer’ in male patients with pelvic fractures. The clinical and radiological JTS sign should not be used in place of radiological imaging.

A limitation is that most studies were retrospective and only one study was prospectively conducted.¹² Another limitation is that 4 of the 9 studies were published as letters or conference abstracts.^{7,8,9,14} Therefore reported data was limited and some of the variables had to be calculated from the available data.

Another limitation to the entity of JTS is the presence of body asymmetry, and genital (penile) asymmetry in particular, which has been observed and documented to be more prevalent in a ‘leftward’ direction in the flaccid state. The handedness of the patient is also associated with a variation of the ‘leftward’ penile pattern observed.^{20,21}

5. Conclusions

Based on this systematic review and meta-analysis, the penile shadow (John Thomas sign) on an AP pelvic X ray is not a reliable “pointer” in determining the laterality of a pelvic or hip fracture.

Conflicts of interest

The authors’ hereby certify that this submission is not under publication consideration elsewhere, and is free from any conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgment

We wish to acknowledge support from Ms Victoria Mtombeni (Department of Radiography, Helen Joseph Hospital, Johannesburg, South Africa)

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